APPENDIX A
SAMPLE CALCULATIONS

A-1. Introduction. This appendix presents calculations that will help an operator manage his land treatment system. The primary concern here is water management: receiving the water into the treatment system, pretreating it, storing it, and distributing it onto the land, with recovery and final discharge if applicable. Also of concern is quality management and energy management. Quality management ensures that the land treatment system is operating within its capabilities, especially the vegetation component, and also satisfies regulatory requirements. The operator can manage energy use by collecting and using power consumption data to make sure that the land treatment system is efficient. This is critical in justifying charges to those people who must pay for the system.

A-2. Water management. Land treatment systems generally consist of three major components, each of which can take several different forms (fig. A-1). Pretreatment can be almost any conventional process, from simple bar screens to primary clarifiers to an activated sludge plant. This is particularly true where the land treatment component has been added to an existing wastewater treatment plant to upgrade or expand it. The purpose of pretreatment is to prepare the wastewater for application onto the land, and to protect the distribution system that discharges the wastewater to the land (pumps, nozzles, weirs, etc.). Operation and maintenance of conventional processes are covered adequately elsewhere. In many modern land treatment systems, pretreatment and storage are combined in a pond, usually of multiple cells. Alternatively, two or more ponds may be provided, the first for pretreatment and the last for seasonal or emergency storage. In general, treatment ponds will maintain a constant depth, whereas storage ponds will vary in depth. Depending on state standards, most ponds are lined to prevent seepage.

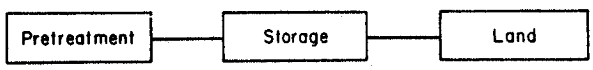

Figure A-1. Major components of a land treatment system.

A-3. Ponds. Calculations helpful in managing the pond system are area-depth-volume relationships and water balance equations for the pond system.

$$V = Ad \text{ (at any time t)} \tag{1}$$

where

V = volume of pond (ft^3)
A = surface area (ft^2)
d = depth (ft).

a. For example, in a pond with an area of 10 acres and a depth of 6 feet, the volume of water contained is

$$V = Ad = (10 \text{ acres})(43{,}560 \text{ ft}^2/\text{acre})(6 \text{ ft}) =$$

$$(2{,}613{,}600 \text{ ft}^3)(7.48 \text{ gal./ft}^3) = 19{,}549{,}728 \text{ gal.}$$

The change in volume for a pond over a given time can be obtained by making a water balance for the pond — essentially accounting for all of the water entering and leaving the pond system:

$$\Delta V = Q_i + P - Q_o - E - S \qquad (2)$$

where

ΔV = change in volume over time t (ft^3)
Q_i = influent wastewater to the pond (ft^3/unit time)
P = precipitation over time t (in.)
Q_o = effluent from pond to land (ft^3/unit time)
E = evaporation over time t (in.)
S = seepage over time t (in.).

Note that P, E and S are depths, and that equation 1 can be used to translate these depths into volumes of water entering the pond.

b. Although an operator cannot control any of the parameters in equation 2 except Q_o, use of these equations, combined with depth measurements of the storage pond and knowledge of the overall system, can give the operator knowledge of when to apply wastewater and how much to apply (within the design limits of the system). It can also give early warning about possible leaks in the storage components, and leaks, infiltration or major new discharges in the collection system.

A-4. Land. Management of water on the land component of the treatment system is constrained primarily by climate and the percolation capacity of the soil. These elements, as well as others, were accounted for during the design of the land treatment system. Key elements in managing the land component of the treatment system are Hydraulic Loading Rate (HLR) and Application Rate (AR). HLR is the amount of wastewater to be applied to the land per year or month (ft/year or ft/month). AR is the depth of water to be applied during each loading cycle (in.). In rapid infiltration and slow rate systems, it is essential that several days without application be allowed between loading cycles so that aerobic conditions in the root zone and soil profile are restored. In overland flow systems, there may be daily loading with no application at night and on weekends. In order to calculate the amount of water to apply during a given loading cycle, it is necessary to know the HLR and the application frequency.

$$V = \left[\frac{HLR}{f}\right] [A][43{,}560 \text{ ft}^2/\text{acre}] \qquad (3)$$

where

V = volume during one loading cycle (ft^3)
f = frequency of application (times/month)
HLR = hydraulic loading rate (ft/month)
A = field area (acres).

For example: A = 25 acres, f = once/week and HLR (for July) = 1 ft. How much wastewater should be applied during each weekly loading cycle?

$$V = (1\ ft)(25\ acres)(43{,}560\ ft^2/acre) = 1{,}089{,}000\ ft^3$$

July has 31 days, or:

$$\frac{31\ Days}{7\ days/week} = 4.3\ weeks.$$

Weekly loading:

$$1{,}089{,}000\ ft^3 \div 4.43\ weeks = 245{,}823\ ft^3/week\ \text{or}\ 1{,}839{,}356\ gal./week.$$

The calculated amount represents the volume to be applied to the field area during 1 week. If the land application site is zoned into areas or basins that are to receive wastewater one at a time, the volume to be pumped during 1 day is divided by the number of basins, and the number of pumping days is equal to the number of basins.

A-5. Water quality. It is important to know how much of various wastewater constituents, particularly nutrients, is actually being applied to the land on a mass basis. To accomplish this, the concentration of the constituent in the applied wastewater must be known as well as the amount of wastewater applied to the land.

$$M_x = (2.72)(c_x)(HLR)$$

where

M_x = mass of constituent x (lb/acre) applied to the site

c_x = concentration of constituent x (mg/L) in the applied wastewater

HLR = hydraulic loading rate of the applied wastewater (ft/month)

2.72 = conversion factor, to convert units to a mass basis.

Example: Area = 30 acres, HLR for July = 1 ft, c_x = total nitrogen = 25 mg/L. How many pounds of nitrogen per acre are applied during the month of July?

$$M_n = (2.72)(25\ mg/L)(1\ ft) = 68\ lb/acre\ per\ month.$$

The total amount of nitrogen applied in July is:

$$\text{Total nitrogen} = (68 \text{ lb/acre})(30 \text{ acres}) = 2040 \text{ lb.}$$

Note that in this example total nitrogen concentration was given. It is acceptable to assume that the sum of total Kjeldahl nitrogen (TKN) and nitrate (both as N) is approximately equal to total nitrogen. The basic equation is valid for all wastewater constituents and can also be used to calculate mass loadings of storage-treatment lagoons.